IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

BE IT KNOWN THAT I, Lakdas Nanayakkara, a resident of the State of Florida and citizen of the United States of America, have invented a certain new and useful improvement in a Blast Protective Barrier System, of which the following is a Specification:

BACKGROUND OF THE INVENTION

1. Area of Invention

The invention relates to protective barrier systems.

2. Prior Art

A long-standing concern with respect to terrorist attacks upon so-called soft targets has become that of the now well-known suicide bomb truck which is simply driven into such a target and then detonated. As such, a need has arisen for a barrier system having high blast and penetration resistance which may used in the protection of a wide variety of potential targets including, without limitation, oil tanks, harbors, and buildings of various types. Also, because most of such attacks originate from ground level, it is not necessary that the height of such a barrier system be equal to the height of the target to be protected.

The limited prior art which exists in the present area is reflected in U.S. Patent No. 4,433,522 (1984) to Yerushalmi, entitled Blast And Fragment-Resistant Protected Wall Structure; No. 5,117,600 (1992) also to Yerushalmi, entitled Building Structure

Having High Blast and Penetration Resistance; and No, 6,224,473 (2001) to Romig, entitled Explosion Relief System Including Explosion Relief Panel. Said reference to Yerushalmi '600 is the most directly known precursor to the instant invention. Therein, a filling material such as loose sand, gravel, pebbles or stones is interposed between opposing concrete panels to form a basic barrier structure. The instant system therefore builds upon the invention of Yerushalmi '600 in its provision of a more economic, modular and flexible system of blast barrier protection.

Other approaches to the problem of blast resistance have appeared in the form of special purpose fillers for placement within walls of structures and, as such, are reflected in U.S. Patent No. 4,589,341 (1986) to Clark, et al entitled Method For Explosive Blast Control Using Expanded Foam; No. 4,763,457 (1988) to Caspe, entitled Shock Attenuating Barrier; and No. 5,214,894 (1993) to Glesser-Lott, entitled Wall Construction of a Non-Load Bearing External Wall. The instant invention thereby presents a system in which the void space between opposing panels may, in addition to the use of the loose filling materials taught by Yerushalmi '600, also employ foam-like materials as is taught by Clark as well as cellular units having high viscous damping as is taught by Caspe above.

SUMMARY OF THE INVENTION

Taught herein is a blast protective barrier system, sometimes termed a blast wall, which is definable in terms of an x, y, z coordinate system. Said system includes a plurality of substantially ground level (xy plane) pile caps, each itself comprising an x-axis elongate length, a y-axis width, and a z-axis depth, said x-axis length substantially defining the width of the barrier system. Each pile cap also includes an upper and lower xy plane surface, each of said upper surfaces including y-axis channels and each of said lower surfaces including a plurality of recesses. The inventive system also includes a plurality of yz plane, y-axis elongate vertical concrete panels having an x-axis width, each panel pair having a lower y-axis edge proportioned for press-fittable securement within said y-axis channels of said upper xy surfaces of said pile caps. Positioned between opposing pairs of concrete panels is a volume of high shock-absorbent material, which material may take a wide variety of different forms including, without limitation, loose sand, gravel, pebbles, stones, inflatable and non-inflatable foams, enclosed cellular units having properties of high viscous damping, and a variety of acoustical and thermal insulative materials which also possess properties of shock and blast absorption. The system further includes a plurality of substantially z-axis elongate piles, each having z-axis upper ends thereof proportioned for securement within said recesses of said lower xy plane surfaces of said pile caps. Opposing xz plane surfaces of said panel pairs at ends of panel groups may be secured to each other either through the use of interpositioned z-axis vertical columns. Said piles which attach to said lower surface of said pile cap are positioned

within a trench as deep as about 50 feet and then backfilled to form a foundation upon which said panels and medially positioned volume of high shock absorbent material are disposed.

It is accordingly an object of the invention to provide a blast protective barrier system which will protect substantially any ground level target from a ground level attack including direct impact by a vehicle loaded with explosive.

It is another object to provide a blast protective barrier system having general utility in a wide variety of security applications.

The above and yet other objects and advantages of the present invention will become apparent from the hereinafter set forth Brief Description of the Drawings, Detailed Description of the Invention and Claims appended herewith.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective fragmentary end view of the inventive system.

Fig. 2 is a vertical cross-sectional view taken along Line 2-2 of Fig. 1

Fig. 3 is an enlarged vertical cross-sectional view of the pile cap shown in Fig. 2.

Fig. 4 is a horizontal cross-sectional view of a concrete panel of the system taken in the direction of Line 4-4 of Fig. 1.

Fig. 5 is a horizontal cross-sectional view showing one method of securement of opposing xz plane end faces of opposing panel pairs of the present system.

Fig. 6 is a top plan view of the vertical column shown in Fig. 5.

Fig. 7 is a foundation plan of the present system taken along Line 7-7 of Fig. 1 and also showing a typical number of pile caps and associated structures associated with a single unit of the system.

Fig. 8 is a concrete barrier plan of the system taken along Line 8-8 of Fig. 1.

Fig. 9 is a top schematic view showing a second method of securement of opposing xz plane end faces of opposing panel pairs.

Figs. 10 and 11 are top plan views showing the manner in which the inventive system may be used to protect selected structure.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the perspective view of Fig. 1, the present inventive blast protective barrier system is definable with reference to an x, y, z coordinate system (which is shown to the lower right of Fig. 1). Therein, the subject system may be seen to include a plurality of substantially ground level (xy plane) pile caps 10, each comprising a x-axis elongate length (see also Figs. 2 and 3), a y-axis width and a z-axis height. The length of each pile cap 10 substantially defines the width of the inventive system within the x-axis. As may be particularly noted, each pile cap 10 includes upper and lower xy plane surfaces 12 and 14 respectively. Said upper xy plane surfaces 12 exhibit y-axis channels 16 into which concrete panels 18 and 20 (described below) are secured at between 5 and 15% of the height thereof. Within lower xy plane 14 of pile cap 10 are provided a plurality (preferably three) of recesses 22 into which are secured a corresponding plurality of piles 24. In a preferred embodiment, a center pile 26 is aligned with the z-axis or gravity vector, while left and right piles 28 and 30 respectively are offset from the z-axis by an angulation falling in a range of about 15 to about 30 degrees.

As may be noted in Figs. 1 and 3, pile cap 10, after securement to its piles 26, 28 and 30 is constructed as driven or augercast piles, and then back-filled so that earth 32 is then compressed about the piles and pile caps forming a stable foundation for the structure as below described.

As above noted, the inventive blast protective barrier system includes said yz plane, y-axis panels 18 and 20. However, in another embodiment, a third panel placed medially between said panels 18 and 20. As may, more particularly, be noted in Fig. 4, each panel 18 or 20 is defined by a x-axis width and a y-axis length having a length-to- width ratio of approximately 10 to 1. A preferred y-axis length of panel 18 or 20 is about 16 inches. Said panels 18 and 20 are also characterized by the use of vertical rebars 34 and of horizontal, xy plane rebars 36. The function of the vertical rebars is that of reinforcement of the concrete of which panels 18 and 20 are typically formed. The primary function of horizontal rebars 36 is to permit z-axis elongate columns 38 to be poured between opposing xz plane surfaces 40 of panels 18 and 18.1, and 20 and 20.1. Said columns 38 are shown in top, xy plane view in Figs. 5 and 6 as are vertical rebars 42 within each column 38. To provide for appropriate z-axis offset between panels 18 and 20, each column 38 will typically exhibit a z-axis dimension having a ratio of about 5 to 1 relative to the z-axis dimension of each panel 18/20, thereby allowing a void space in a range of about 45 to about 50 inches between each panel 18 and 20. See Figs. 1, 7 and 8.

Between concrete panels 18 and 20 is provided a volume of high shock-absorbent material such as sand, dirt, gravel, pebbles, special-purpose blast suppressing foam barriers, as is taught in U.S. Patent No. 4,589,341 to Clark , and special shock attenuating cellular elements of the type taught in U.S. Patent No. 4,763,457 to Caspe, et al.

With reference to Fig. 7, there is shown a foundation plan of the inventive system. Therefrom, it may be appreciated that a typical unit of the present blast protective barrier system will consist of pile caps 10, 10.1, 10.2, and 10.3 and their above-described corresponding piles 24 and vertical panels 18 and 20 (see also Fig. 8).

Cut expansion joint columns 38 are not used for the joinder of opposing xz surfaces 40 of panels 18/20, a two end columns are constructed with space for expansion as shown in Fig. 9.

It should be further appreciated that certain other salient dimensional relations exist in the above-described system. Therein, a xz plane of each pile cap 10 in cross-sections of panels 18/20 define a ratio of x-axis pile cap dimension to separation of an opposing panel in a range of about 1.5:1 to about 2.5:1, in which about 3.5:1 has been found to be preferable. Further, the xy plane of each pile cap defines a ratio of between about 3:1 and about 1:1 relative to the x-axis width of each panel 18/20. It is further noted that in an xz plane of each panel pair, inclusive of said interposed volume of shock absorbent material, total aggregate x-axis dimension of outer surfaces of said panels to said compacted material comprises an x-axis range of between about 2.5:1 and about 1.5:1. Preferably, and particularly for purposes of ease of production, panels 18 and 20 will be identical and width and other respects. It is further noted that a x-axis depth of lower ends 50 (see Fig. 2) which are within said pile cap channels 16 will comprise a ratio in a range of about 0.05 to about 0.15 of the entire z-axis height of the panels 18/20, in which the ratio 0.07 is preferable.

The depth of piles 24 within earth 32 will typically be within a range of about 10 to about 50 feet in which the separation of the tops 52 of each pile within said recesses of the pile cap may define an aggregate length of about 10 feet. As may be noted in Fig. 6, a ratio of pile cap 38 x-axis length to y-axis width will define a range between about 3.5:1 and 2.2:1. As may be noted in Figs. 4 and 6, the y-axis width of column 38 will typically slightly exceed the x-axis width of panels 18/20.

It is further noted that the height of each panel 18/20 are typically within a range of about 8 to about 15 feet, thereby providing sufficient height to protect a terrorist target from the vehicle of considerable height that may be filled with explosives.

It has been also determined that the ratio of z-axis height of each panel 18/20 to the x-axis length of each pile cap 10 may be approximately equal but, more particularly, will reflect a range of about 0.7:1 to about 1.2:1. Thereby, the foundation of the instant structure, in combination with the above-described pilings 24 will afford enormous lateral stability to the present structure in the event of an explosive attack or a direct armored assault by a tank, tank artillery or other state of the art ground-to-ground artillery. The structure will of course also provide a defensive perimeter in the event that security personnel are available at the time of such attack.

As above noted (see Fig. 2), the angulation of outer legs 28 and 30 relative to center legs 26 will generally fall within a virtual cylinder defined by the greatest x-axis dimension of pile cap 22. However, where earth 32 is not sufficiently stable or if

it is not feasible to dig deeply into the earth, the angualation of the outer legs relative to the center leg 26 may be increased substantially, as may the number of pile provided beneath each pile cap.

The preferred construction method associated with the above system is:

1. Install piles 24 to the required depth to withstand gravity and critical load.

2. Construct pile caps 10 with grooves 16 on each side (full width or partial width) to receive pre-cast concrete wall panel 15' to 25' long.

3. Make pre-cast concrete panels 18/20 with extended rebars at each end and at bottom of panels with or without the extended rebar.

4. Set pre-cast panel within a groove of the pile cap and lock it in place.

5. Pour concrete connector wall between wall panels on top of pile caps at each pile cap location. Use shape of a letter "I" to connect to both wall panels and foundation.

6. At every 100' to 120' provide expansion joint within the wall by construction of shape][(double channel back-to-back), with an expansion joint in which a seal chemical compound is used to accommodate expansion and contact of the wall and to withstand high pressure.

7. Fill the space between the wall panels with loose sand or selected fill material to absorb impact.

8. Connect the top of the walls with the concrete slab with cast-in-place or pre-cast concrete panels to act as twin wall on one unit on top of the walls.

9. If only single panel wall is to be used, no backfilling nor top slab is required.

While there has been shown and described the preferred embodiment of the instant invention it is to be appreciated that the invention may be embodied otherwise than is herein specifically shown and described and that, within said embodiment, certain changes may be made in the form and arrangement of the parts without departing from the underlying ideas or principles of this invention as set forth in the Claims appended herewith.